A NEW SPECIES OF *EURYCEA* (AMPHIBIA: CAUDATA) FROM THE SOUTHEASTERN UNITED STATES

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Morphologically, the plethodontid genera *Eurycea* and *Pseudotriton* are related closely (Dunn, 1926). *Eurycea* typically has unfused nasal processes of the premaxilla, discontinuous prevomerine and parasphenoid teeth, nasals in contact with the maxillae, no prootic-squamosal crests, a slender body, and long tail. *Pseudotriton* is considered less specialized, and has fused nasal processes of the premaxilla, prootic-squamosal crests, nasals separated from the maxillae by the prefrontals, and continuous prevomerine and parasphenoid teeth. In addition, *Pseudotriton* is stocky-bodied, short-tailed, and exhibits no sexual dimorphism.

Within the genus *Eurycea* there are three natural assemblages: group 1 includes the brook salamanders, *E. bislineata* and *E. multiplicata,* species that usually reside near the edges of streams beneath rocks and leaves; group 2 contains the long-tailed salamanders, *E. longicauda* and *E. lucifuga,* species essentially terrestrial but also found close to water; group 3 includes the neotenic forms, *E. nana, E. neotenes, E. troglodytes,* and *E. tynerensis,* species that retain larval characters throughout life. Thus, each group occupies a somewhat different habitat (with overlap), either metamorphoses and leaves the water, or remains in the water as a breeding larva.

The new *Eurycea* described herein apparently is aquatic and yet undergoes normal metamorphosis. Many of its cranial features are shared with salamanders of the genus *Pseudotriton.* For this new salamander we propose the name:

EURYCEA **AQUATICA,** sp. nov.

Holotype.—USNM No. 147138, collected October 6, 1962, by Francis L. Rose, Francis M. Bush, and James Jackson.

Type locality.—Small springs and permanent streams two miles west of Bessemer, Jefferson County, Alabama, along county highway 20

Paratypes.—All paratypes have the same collection data as the holotype. USNM 147139-147141; UMMZ M123349, M123350; CNHM 134998, 134999; AMNH A69032, A69033; CM 38647, 38648; UF 14907-14909; TU 18765 (65 specimens).

Diagnosis.—A moderate-sized stocky *Eurycea* (fig. 1) with a brownish dorsum, dusky-black sides and lightly stippled to immaculate venter. A dorsal light band extends to the tip of the tail and is bordered by the black edge of the lateral ground color. The legs are short but well developed, there are 13 costal grooves, from two to four costal grooves between adpressed limbs, and a tail usually shorter than the snout-vent length. The new species resembles *E. bislineata* but differs from that species in coloration, in being much stockier, in having a shorter tail, fewer prevomerine teeth, high percentage of adults with continuous prevomerine and parasphenoid teeth, fused nasal processes of the premaxilla, and prominent prootic-squamosal crests. In addition, *E. aquatica* produces more eggs per individual and sexual maturity is attained near transformation.

The characteristic pattern and short tail distinguish *E. aquatica* from *E. longicauda* and *E. lucifuga.* The lower number of costal grooves makes it discernible from *E. multiplicata* and the ability to undergo normal transformation separates it from the neotenic species.

Description of holotype.—An adult male with the following characters: total length, 85.5 mm; snout-vent length, 44.8 mm (tip of snout to anterior angle of vent); tail compressed and short, relative tail length, 0.91; head length, 9.9 mm (tip of snout to mid-ventral edge of gular fold); head width at angles of jaws, 6.4 mm; gular width, 8.0 mm; 13 costal grooves; 4 costal grooves between adpressed limbs; fingers $3<2<4<1$ and toes, $3<4<2<5<1$; prevomerine teeth on left side, 7; prevomerine teeth on right

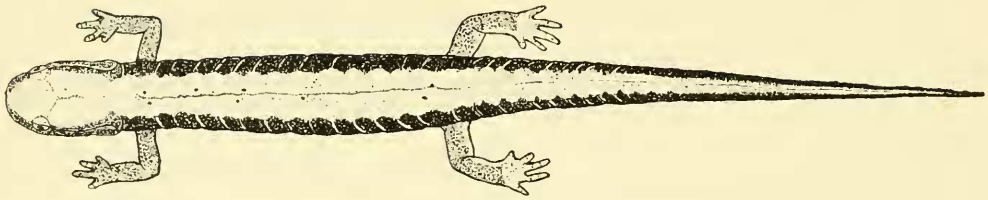

Figure 1. Dorsal view of adult female *Eurycea aquatica*, sp. nov.

side, 8; dorsal light band, in life, Brussel's Brown (Ridgway, 1912); lateral ground color, black. There are short cirri and numerous dark specks within the dorsal light band. The digits of the right forelimb and left hindlimb are slightly deformed.

Variation.—Size: The longest specimen, a male, is 48 mm (snout-vent lengths are given throughout this report unless otherwise stated and were measured from the tip of the snout to the anterior angle of the vent), four millimeters longer than the next longest specimen (fig. 2). The shortest transformed male is 28 mm; the shortest female, 29 mm. The longest larva, a female, is 36 mm. Seven larval males longer than 28 mm have large black testes and black, coiled vasa deferentia; these are considered sexually mature. Six larval males longer than 28 mm have small white testes and are considered immature. Twenty larval females longer than 28 mm have enlarged ova with small yolk deposits, ten others show no egg development. All larvae showing signs of gonadal development have an adult pattern. One transformed male (28 mm) is im-

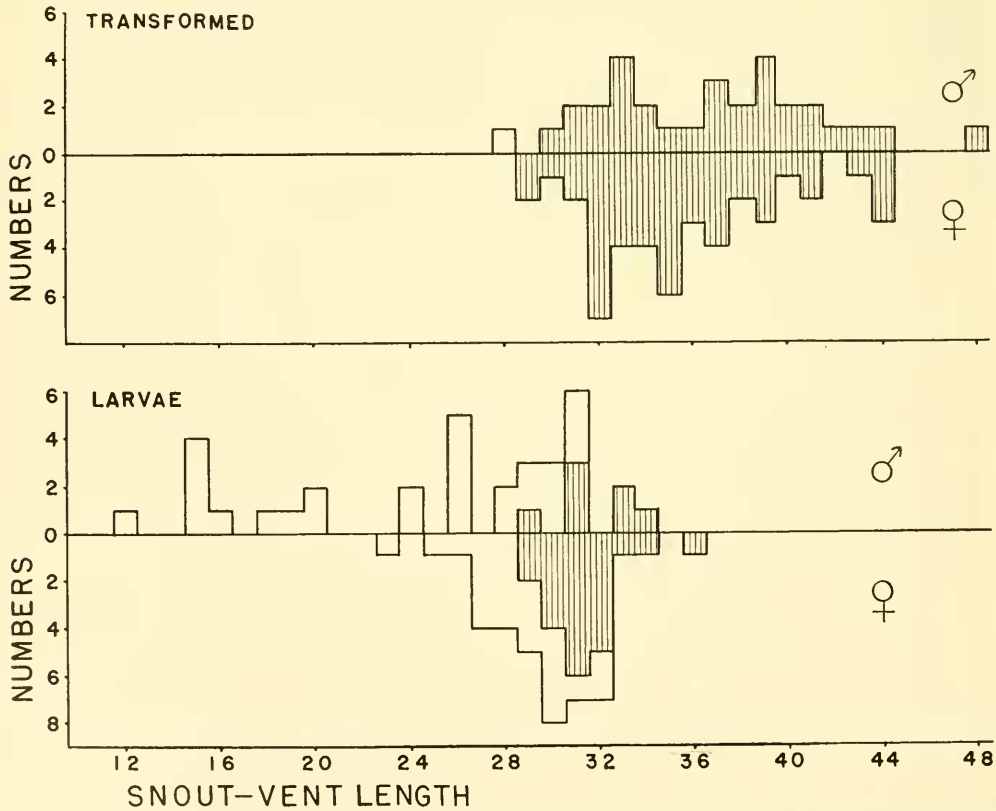

Figure 2. Distribution of snout-vent lengths in larval and adult *E. aquatica*. Vertical lines indicate animals showing gonadal activity. Measurements in millimeters.

mature, but has an adult pattern. These data are indicative of precocious reproductive development and not true neoteny.

Relative tail length: The relative tail length (fig. 3) is the difference between the total length and snout-vent length, divided by the snout-vent length. Relative tail lengths of 38 adults average 0.94 (0.80-1.14). Only 11 specimens have a tail longer than the snout-vent length. Thus, *E. aquatica* is the shortest-tailed *Eurycea* that undergoes normal transformation. The average relative tail length of 30 adult *E. bislineata* from Alabama is 1.34 (1.11-1.57).

Color: Colors are based on Ridgway's color standards. The dorsum varies from Buckthorn Brown to Raw Umber and Brussel's Brown. In most specimens, the dorsal base of the tail appears Lime Green, Olive Yellow, or Empire Yellow. The sides of the body and tail are black and, in most specimens, the sides of the tail are darker than the sides of the body. Usually there is a row of light spots along the sides of the body and tail. Most specimens are uniformly brown on the dorsum of the limbs. The venter may be clear, Wax Yellow or Strontian Yellow; the chin is mottled with black, intensely so in old males.

In preservative the bright colors fade quickly. The dorsum becomes various shades of dull brown and the lateral black ground color lightens.

Skull: The skull of *E. aquatica* is distinctive. The most significant difference from other *Eurycea* is the fused nasal processes of the premaxilla (fig. 4). In 11 of 12 large mature individuals, the processes are fused solidly. In three transforming specimens they are separate, and in two others they are slightly fused. All larvae have unfused processes, suggesting that fusion is associated with transformation. The premaxillary fontanelle is well developed and there is a "V" shaped notch in the posterior projection of the fused processes.

Wilder (1924) reported four per cent of *E. bislineata* from Massachusetts had fused nasal processes of the premaxilla but the degree of fusion was not associated with a particular developmental stage. Six adult *E. bislineata* from Alabama, two from northeastern Mississippi, and three from southern Louisiana, have unfused processes. One adult from Butler County, Alabama, has fused processes. Seven *E. longicauda* and five *E. lucifuga* lack fused processes.

A significant feature of *E. aquatica* is the

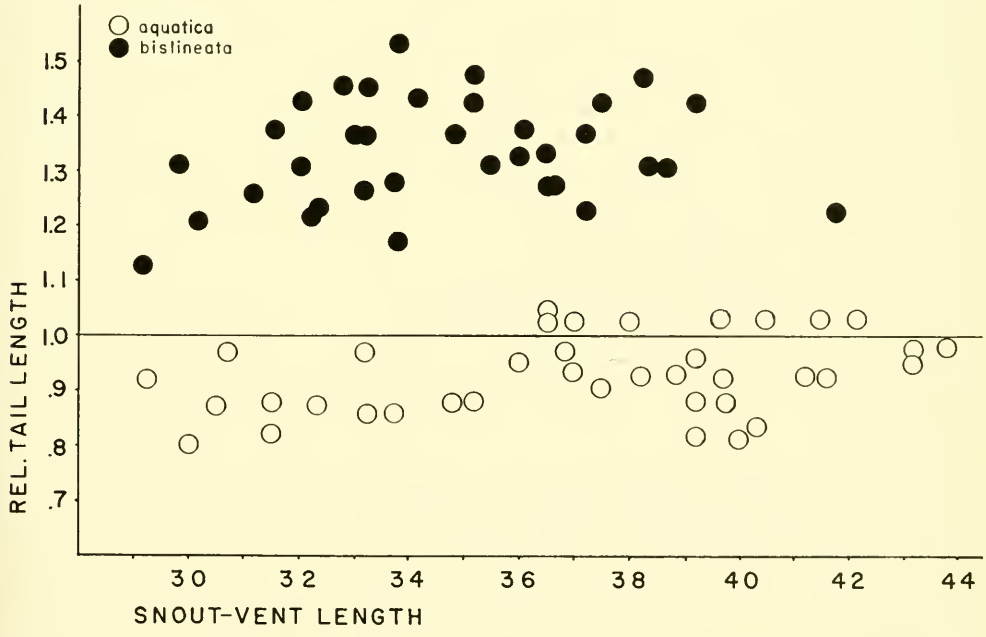

Figure 3. The relationship of snout-vent length to relative tail length in *E. aquatica* and *E. bislineata*. A large male *E. aquatica* (48 mm) with a relative tail length of 1.14 is not represented.

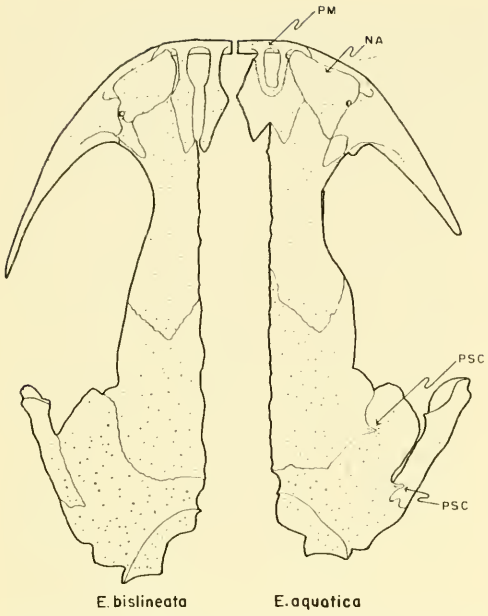

Figure 4. Dorsal view of the skulls of *E. bislineata* and *E. aquatica*. Only one-half of each skull is represented. Differences in the nasals are due to individual variation. The septomaxillae have been omitted. (PM = premaxilla, N = nasal, PSC = prootic-squamosal crests)

presence of prominent prootic-squamosal crests. These occur on ten of the 12 adults stained and cleared. *Pseudotriton, Gyrinophilus,* and *Aneides* are the only North American plethodontids previously known to have these crests (Dunn, 1926).

A third distinctive feature is the short, thick maxilla. Four *E. aquatica* and four *E. bislineata* with the same snout-vent lengths were measured to determine the extent of lengthening of these elements. This feature is best measured along a line from the tip of the snout to a line drawn across the tips of the maxillae. The maxillae of *E. aquatica* are approximately 17 per cent shorter than those of *E. bislineata.*

Teeth: The prevomerine and parasphenoid teeth of *Gyrinophilus* and *Pseudotriton* are continuous. They are also continuous in *Eurycea* shortly after transformation. This continuity results from the posterior growth of the prevomers along the roof of the mouth with subsequent incorporation of the parasphenoid. The connection is transitory and, "soon after transformation the slender rod of bone which connects the growing parasphenoid tooth patches with the body of the vomer undergoes atrophy" (Wilder, 1925). The subsequent separation into two distinct series was considered a derived character by Dunn (1926).

The number of prevomerine teeth of ten adult male *E. aquatica* average 11.0 (8-15); 13 females, 10.6 (6-13). Nineteen adults (45.2 per cent) have continuous prevomerine and parasphenoid teeth; however, the connecting teeth are relatively small. In accordance with Wilder's observations one would expect the shortest animals to have the continuous series; this is not the case. Animals with continuous series are represented in all size groups, from 32.0 to 44.0 mm. In contrast, only the shortest transformed *E. bislineata* (below 32.0 mm) have continuous series.

The number of prevomerine teeth in 16 adult male *E. bislineata* from Alabama and Louisiana average 16.2 (11-19); 18 females, 17.1 (15-20). Although there is an overlap between some specimens of *E. aquatica* and *E. bislineata* in this character, *E. aquatica* has about 35 per cent fewer teeth.

Fecundity.—The reproductive potential of *E. aquatica* is high (Table 1). The average number of eggs, in corpora, for seven females is 80 (60-96). In contrast, the average number of eggs for seven *E. bislineata* from Alabama and Louisiana is 52 (40-59). The latter data are in partial agreement with those of Wood and Duellman (1951) for *E. bislineata* from Ohio. They found the number of large ova per female ranged from 22 to 95 and there was a correlation between snout-vent length and the number of large ova ($r = +0.462$). The average number of eggs for Ohio specimens between 30 and 35 mm (tip of snout to

TABLE 1.
The relationship between number of enlarged ova and snout-vent length in E. aquatica and E. bislineata from Alabama. Measurements in millimeters.

aquatica		bislineata	
Snout-vent	No. large ova	Snout-vent	No. large ova
36.1	80	35.2	40
38.4	60	38.0	59
39.2	73	38.1	50
41.0	81	42.5	57
42.5	80	43.2	52
43.1	96	44.0	46
43.3	90	45.1	58

posterior angle of vent) was 35; for animals above 45 mm, 57 ova. When the ontogenetic increase of egg number is considered, *E. aquatica* has considerably more eggs per female than either northern or southern *E. bislineata.*

Habitat and habits.—The type locality is a series of small, natural springs that converge to form a stream. The water is clear, has an average yearly temperature of less than 60°F, and attains a velocity of 3.5 ft./sec. in the swiftest part of the stream. The spring and stream beds are mostly gravel and sand, but silt accumulates in several sections. Near the middle of the stream there is a heavy growth of water cress, *Nasturium officinale;* most of the adult *E. aquatica* were collected here. They remained hidden among the entangled roots below the surface. Larvae resided near or on the gravel or sandy bottom. A few adults and many larvae were collected along the shallow edges where sand had accumulated; here the dominant plant was wild spearmint, *Mentha spicata.* Individuals seem to avoid the silted areas almost entirely, and none was found along the stream bank.

Other amphibians found along the stream or in its vicinity were *Pseudotriton ruber, Gyrinophilus porphyriticus,* and *Desmognathus fuscus.* Two *Ambystoma tigrinum* and one *Gastrophryne carolinensis* were collected near the spring source.

Inasmuch as the new species somewhat resembles *E. bislineata,* attempts were made to collect the latter, at or near the type-locality. Two adults were collected only eight miles east of the type locality and two others examined from the University of Alabama collections (48-492, 48-493) were collected from Jefferson County, Alabama. All have well developed dorsolateral stripes bordered by yellow; in two the tails are long (average relative tail length, 1.29), and two have broken tails. Numerous larvae were collected throughout Jefferson County.

Description of larvae.—Larval coloration and pattern are variable. The small larvae are black with a clear venter. As ontogeny proceeds the dorsal coloration lightens, becoming brownish; the sides remain dark. The adult dorsal pattern and coloration become evident as transformation and sexual maturity near. Thus, larval coloration varies from black to brownish and dorsal pattern from indistinct to the condition found in adults.

There is a dark, irregular stripe posterior to the eye, and a row of tiny spots dorsal to the limbs. The lower row of small spots found on most *E. bislineata* larvae is absent. A few larvae have the two rows of dorsal spots as in *E. bislineata,* but the majority do not. The tail fin, although well developed, is not as high as in *E. bislineata* larvae (fig. 5).

The larval pattern of *E. aquatica* is darker and less reticulate laterally than that of *E. bislineata.* Examination of larval *E. bislineata* from the Piedmont of Georgia, showed that transformation may occur at a large size; however, none was observed with an adult pattern.

Phylogenetic considerations.—The status of the premaxilla as a phylogenetic indicator among plethodontids is not clear.

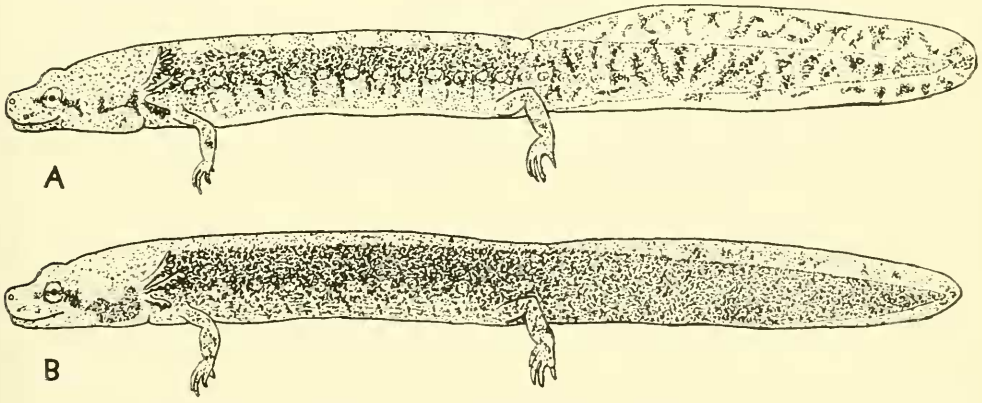

Figure 5. Lateral view of larval (A) *E. bislineata* and (B) *E. aquatica* from Jefferson County, Alabama. Larvae are approximately 24 mm.

Wilder (1924) stated the element was too variable to indicate relationships. Among plethodontids, however, three patterns are evident; maintenance of the presumed primitive condition, fusion of parts, and separation of parts (fig. 6).

Plethodontids have premaxillae that form as single elements (Martof and Rose, 1962). At formation the element is shaped like the Greek letter pi (π). This type of premaxilla is probably the primitive plethodontid premaxilla (Grobman, 1959), not the paired structure as Dunn (1926) thought. Among the eastern boletoid-tongued plethodontids, *Eurycea* and *Manculus* retain this primitive pattern. In *Gyrinophilus,* the dentigerous corpus of the premaxilla separates early and the nasal processes remain unfused. *Pseudotriton* retains the solid corpus and the nasal processes fuse solidly. Thus, fusion or separation of parts of the premaxilla would be advanced features. *Eurycea,* although advanced in most characters, has maintained the primitive premaxilla, except for *E. aquatica,* which shares other features with salamanders of the supposedly less specialized *Pseudotriton.*

Ensatina, Hydromantes, Plethodon, Hemidactylium, and *Gyrinophilus* are the North American plethodontids that have paired premaxillae as adults. Obviously, this condition has evolved independently several times. *Hydromantes* is the only North American boletoid-tongued genus that we have not considered here. Probably it is related closely to *Gyrinophilus* (Dunn, 1926), but its relationships to eastern genera are not clear.

The dorsal pigment patterns of plethodontids are complex and caution should be exercised in their interpretation. However, this should not impede efforts to better understand pattern relationships where conclusions are justifiable. *Pseudotriton* and *Gyrinophilus,* probably the least specialized plethodontids, have uniform colors with dark speckles. This may be considered a basic pattern as their larvae also have indistinct patterns. *Eurycea* larvae have six rows of spots; four lateral and two dorsal. In *E. aquatica,* the lower rows appear absent. The light dorsal band and dark sides of *E. aquatica* may be a basic *Eurycea* pattern derived from the spotted condition. All of the previously described species of *Eurycea* that undergo normal transformation, except *E. lucifuga,* exhibit modifications of the *E. aquatica* pattern. Many *E. bislineata* pass through a stage immediately after transformation when they have dark sides and a light dorsal band.

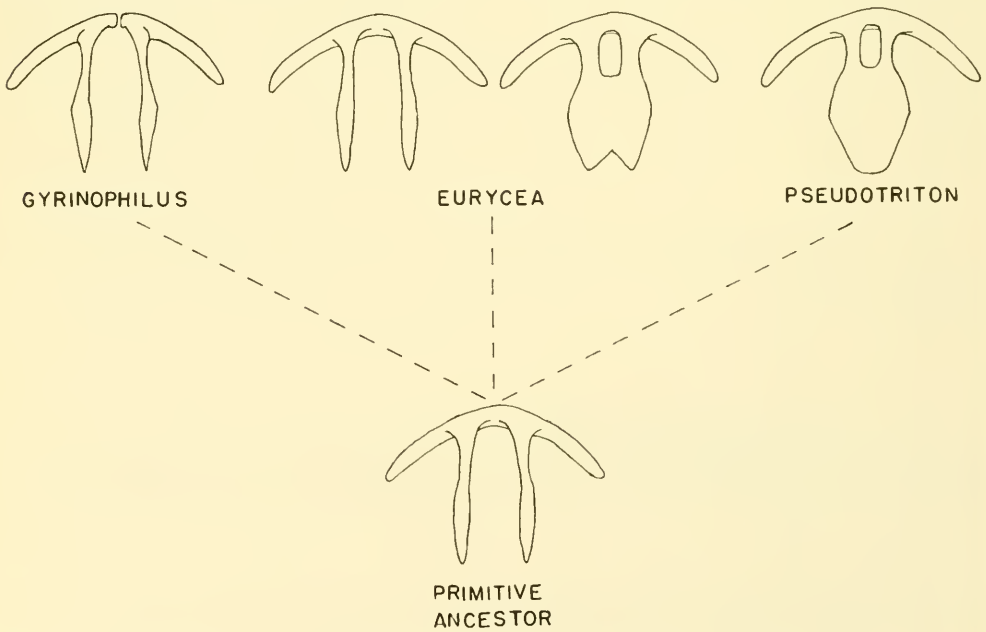

Figure 6. Divergence of the premaxilla as seen in three genera of plethodontids.

However, they soon develop the two dark stripes by pigment intensification along the edges of the dorsal light area and the ventrolateral loss of dark pigment.

Eurycea aquatica could be the product of neotenic evolution. The dorsal pattern, short tail, and continuous prevomerine and parasphenoid teeth in a high percentage of individuals may be larval characters. In addition, the animals exhibit precocious gonadal development. The well ossified skull and fused nasal processes of the premaxilla are not neotenic features. Within a group that characteristically has separate nasal processes of the premaxilla, one would expect a neotenic member also to retain unfused processes; this *E. aquatica* does not do.

Superficially, *E. aquatica* appears to be a morphologically unspecialized *Eurycea,* being somewhat more advanced than *Pseudotriton,* and yet, not as advanced as other *Eurycea.* The premaxilla of *E. aquatica,* however, is not primitive; neither is that of *Pseudotriton.* Obviously, unspecialized forms do not necessarily remain unspecialized in all characters. The similarity of characters between the new species and *Pseudotriton* is due probably to the close relationship among the eastern boletoid-tongued plethodontids, but is not indicative of lines of descent within the group.

Whether *E. aquatica* is unspecialized or has evolved through neoteny cannot be answered. Possibly after other aspects of its life history are known, and a more thorough study of plethodontid osteology is completed, we will be better able to understand the phylogeny of the group.

Distribution.—The range of *E. aquatica* is unknown. The type locality is within the Ridge and Valley Province near the edge of the Cumberland Plateau. To the north, there are numerous springs of the same type found at Bessemer; however, there is no reason to assume the species is restricted to this type of habitat. A series of larvae collected by Dr. Royal D. Suttkus in Chattooga County, Georgia, may be this species, but they are greatly faded. The habitat there is a fast flowing stream containing much aquatic vegetation. Dr. Richard Johnson of the Tennessee Polytechnic Institute informed us he has collected the animals in the Cumberland Plateau region of Tennessee. These observations indicate *E. aquatica* may occur in northwest Georgia, southwest Tennessee, northeast Mississippi (especially Tishimingo County), and northern Alabama.

Methods.—Specimens were killed in chloretone, hardened in ten per cent formalin, and stored in seven per cent formalin. Measurements were made with vernier calipers. At least two weeks elapsed between hardening the specimens and making the measurements to avoid bias by different degrees of shrinkage. The prevomerine teeth were counted with the aid of a binocular microscope after the fluid and mucous within the buccal cavity were blown-out with compressed air. Skeletal preparations were made by clearing, then staining with alizarin red S.

Museum abbreviations are as follows: AMNH = American Museum of Natural History; CM = Carnegie Museum; CNHM = Chicago Natural History Museum; TU = Tulane University; UF = University of Florida; UMMZ = University of Michigan Museum of Zoology; USNM = United States National Museum.

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ABSTRACT

Eurycea aquatica, sp. nov., occurs in the Ridge and Valley Province in Alabama. The new species is superficially similar to *E. bislineata* but differs from the latter by having a shorter tail, stockier body, duller coloration, fused nasal processes of the premaxilla, prootic-squamosal crests, shorter maxillae, and continuous prevomerine and parasphenoid teeth in a large percentage of the adults. The new species apparently is aquatic and specimens mature just prior to transformation. Many cranial features are shared with salamanders of the genus *Pseudotriton*, *e.g.*, the type of premaxilla. The premaxilla probably is not a good indicator of phylogeny, but, among plethodontids three premaxillary patterns are evident; maintenance of the supposedly primitive condition, separation of parts, and fusion of parts.